Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/694
SWITZERLAND
February 1964
Original: FRENCH

Confidential until official release during Conference

Abstract

GAS COOLING FOR FAST REACTORS

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Investigation of the possibilities of gas cooling for fast-breeder power reactors, including design work on a 1250 Mw(t) plutonium-fueled reactor of this type has been carried out at Zurich during the years 1962-1963. Interest in gas cooling for this purpose, apart from the desirability of having an alternate technology for fast reactors avoiding, as yet, unresolved practical engineering and operational difficulties of liquid metals, results from the possibilities for both improved fast reactor core neutronic performance and simplified engineering and operational features.

Core physics studies have shown coolant reactivity effects which are an order of magnitude smaller than for liquid metal cooled systems. This facilitates core designs with unity internal conversion ratio, while avoiding undesirably high positive coolant void and temperature coefficients and permits design for long intervals between refuelings.

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Fast spectrum calculations have been performed with the new GAM II code utilizing 99 fine group cross sections for a range of volumes and compositions. Other results of these calculations show a harder neutron spectrum for gas cooled core designs resulting in an increase of breeding ratio of 0.15 to 0.20 over that with sodium cooled cores.

The results of design studies are presented, including results which show that for cores in the 1,000 Mw(t) range, ratings in the region of 0.7 Mw/kg fissile, together with power densities of the order of 250 Kw/litre are readily obtainable, with helium or CO_2 cooling, at ambient pressures of 68 atmospheres for total pumping power expenditures of no more than 3 % of the thermal output. Investigation of alternate fuels for the system has been made with particular attention given to use of simple, round, stainless steel clad, oxide fuel elements with special design features to accommodate fission gas release for burnups in the 100,000 Mwd/t range. Operating conditions are substantially similar to present projected liquid metal-cooled designs and with maximum fuel element ratings in the 500 to 650 watt/cm range.

Surface roughening of the fuel element cladding is employed in a new, optimized way resulting in reducing the required number of fuel elements by a factor of four, while, at the same time, increasing the core specific power and power density. A new core thermal design code, GAZELLE III, which optimizes surface roughening, was developed to obtain this result.

The use of resonance absorbers, mixed with the core structural material to secure continuous decrease in reactivity with increase of water content, has been studied as a means of

dealing with steam-in-leak, and allowing use of water injection for emergency cooling. Detailed neutron spectrum calculations and reactivity determinations have been made for resonance absorbers including indium for a range of fast to soft spectrums. Appropriate resonance absorbers have small effect on the breeding ratio under operating conditions.

A layout has been made of a 500 Mw(e) power system incorporating a prestressed concrete pressure vessel enclosing the reactor core, series steam turbine driven circulators, and steam generators capable of supplying 565^{o}C steam. Special features are incorporated in the concrete vessel concept to require two independent failures before rapid loss of coolant. Over-all plant efficiency is about 38 %, taking into account coolant pumping requirements.